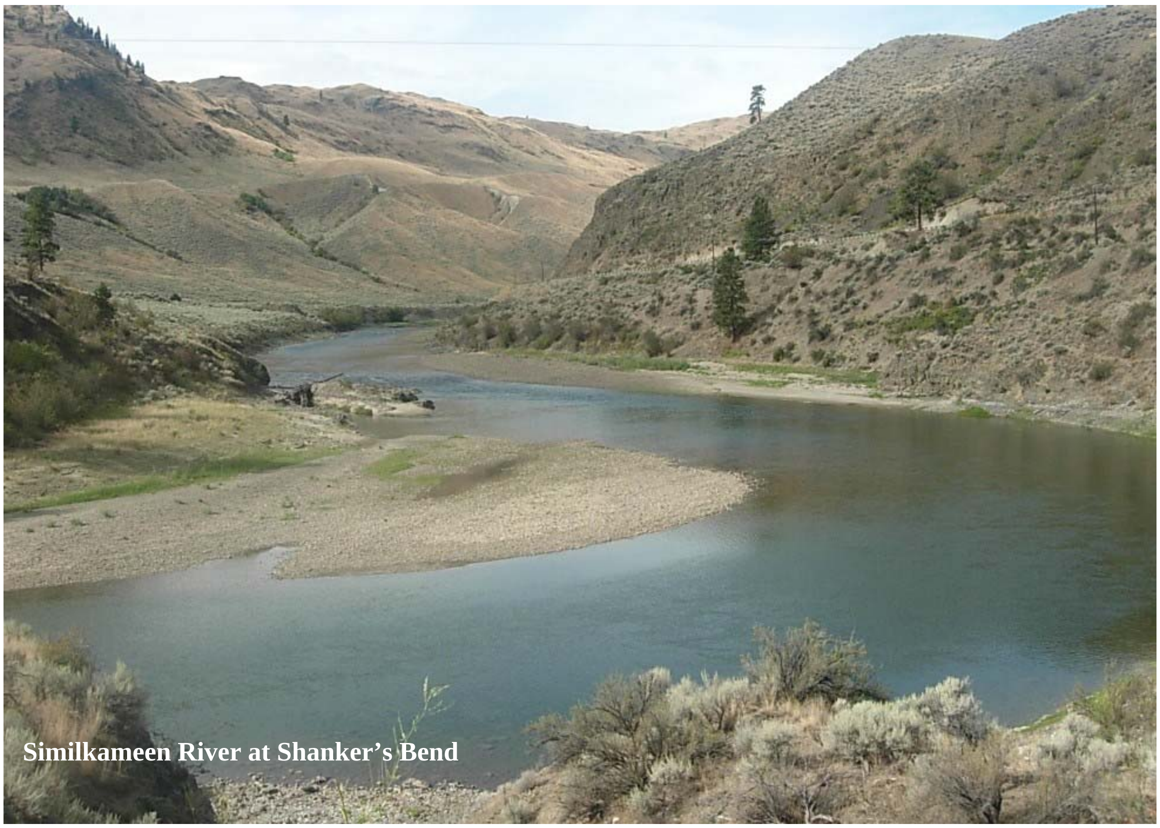
Similkameen River Appraisal Level Study



Similkameen River at Shanker's Bend

APRIL, 2009

EXECUTIVE SUMMARY

This report presents an appraisal level evaluation of three options to develop water storage on the Similkameen River. The potential of each option to generate hydroelectric power and provide flood control benefits is also evaluated. The appraisal is based on existing information and focuses on the major issues that bear on a decision to move forward with further consideration of each option. It identifies data gaps that would require further investigation to establish the feasibility of the options.

The three options selected for consideration are sited at Shanker's Bend on the Similkameen River, about two miles upstream of the Okanogan Public Utility District No. 1 Enloe Hydroelectric Project. The three options considered in this report are identified as the 'High Dam', 'Medium Dam', and 'Low Dam' options, reflecting differing heights of the dam crest. Each option is described below, together with an appraisal of environmental effects and engineering summarized in Table ES-1.

The selection of the three options considered in this report takes account of a long history of project proposals that have been considered at Shanker's Bend, Palmer Lake, Lenton Flats, Railroad Bridge, and other locations on and around the Similkameen River; a history that dates to the 1920's. Alternatives previously considered and eliminated are described in Chapter 2. Among the criteria used to select the options for appraisal evaluation in this report were their cost, engineering, potential environmental effects, and their ability to function well as stand-alone projects. These criteria led to the conclusion that Shanker's Bend is the most suitable location for a water storage, flood control, and hydroelectric project on the Similkameen River.

High Dam

The highest of the three options at the Shanker's Bend site is an earth-fill dam with a maximum reservoir water surface elevation of 1289 feet, 1.3 million acre-feet of active water storage and an estimated annual energy output of approximately 232,000 MW-hrs. This option is similar to a project considered in 1955 by the International Joint Commission (IJC, 1955). The High Dam option is intended to provide the maximum water storage volume for the lower Similkameen River allowed by the available topography and is sufficient to allow capture and attenuation of peak flood flows that would provide significant flood control benefits for downstream reaches. This option would inundate land beyond the United States border into Canada.

The High Dam option would provide the far more water storage, flood control and hydropower benefits than the other options, and would also provide greater benefits to downstream fish and other aquatic resources through summer cool water releases. It would be capable of providing up to 74 MW of installed hydropower capacity; would attenuate floods in all years modeled, would very likely be able to meet temperature standards in the Similkameen River and improve conditions in the Okanogan River, would supply minimum instream flows (greater than naturally occurring flows) in all weeks, and would be capable of providing up to 2000 cfs of additional water in July-September of most years. The High Dam reservoir can offer considerable offsetting recreational benefits as well. Offsetting these benefits, the High Dam option would entail higher costs related to inundation of property and infrastructure, and for mitigation of effects to wetlands, wildlife habitat, and cultural resources. Recreation and engineering/construction issues also could pose important challenges to the project. Engineering alternatives deserving of further consideration, such as roller compacted concrete dam design, could provide both cost and environmental benefits. Because the High Dam would inundate parts of Canada it would require international cooperation and would be subject to Canadian regulations.

Medium Dam

The Medium Dam option is a concrete gravity structure with 138,000 acre-feet of annual water yield,, an estimated annual energy output of 84,000 MW-hrs, and an operating reservoir water surface of 1175 feet which would limit inundation of the reservoir pool within the borders of the United States. The dam would be located in the narrow canyon at Shanker's Bend. The International Joint Commission considered a similar maximum reservoir elevation in 1955 as their 'Low Dam' option.

The Medium Dam option would provide water storage, flood control and hydropower gains without affecting Canada. It has good potential to provide benefits to fish downstream through the release of cooler water during the summer months, although temperature stratification in the reservoir would need to be confirmed through modeling. It would be capable of providing up to 23 MW of installed hydropower capacity; would attenuate floods in 91% of the years modeled, would likely be able to meet temperature standards in the Similkameen River and improve conditions in the Okanogan River, would supply minimum instream flows (greater than naturally occurring flows) in 96% of weeks, and would be capable of providing up to 500 cfs of additional water in July-September of most years. The most important challenges to moving forward with the Medium Dam option are associated with the inundation of land, property, and infrastructure, and potential mitigation requirements for wildlife and wetlands. Recreation and cultural resources remain issues that have the potential to pose considerable challenges as well. However, all of these challenges would be greatly reduced as compared to the High Dam option.

Low Dam

The Low Dam option is a concrete gravity structure with 20,000 acre-feet of annual water yield,, an estimated annual energy output of 70,000 MW-hrs,, and an operating reservoir water surface of 1155 feet. It has a much smaller reservoir pool, contained within the borders of the United States. The dam would be located in the narrow canyon at Shanker's Bend.

The Low Dam option would provide reduced water storage, flood control and hydropower compared to both other options. The benefits to fish downstream through the release of cooler water during the summer months depend upon temperature stratification in the reservoir, which would need to be confirmed by modeling. It would be capable of providing up to 19.6 MW of installed hydropower capacity; would attenuate floods in 76% of the years modeled, may be able to improve temperature conditions in the Similkameen River, and would supply minimum instream flows (greater than naturally occurring flows) in 92% of weeks. The smaller Low Dam reservoir significantly lessens concerns raised by the inundation of land, property, and infrastructure, as well as potential mitigation requirements for wildlife and wetland habitats, recreation sites and cultural resources. However, important potential effects remain in each area that would need to be addressed in permitting and Settlement Agreement processes.

Project Benefits

Table ES-2 summarizes important benefits of the Similkameen project for each of the three options under consideration. Water storage benefits include up to 1.3 M acre-feet of usable water storage (under the High Dam option) and the capacity to generate as much as 74 MW (average annual generation of 232,000 MWh) of clean, renewable power with very low carbon emissions. The project could also provide flood control, depending upon its operations plan, attenuating flood damage to communities downstream.

Water storage can be used to meet minimum instream flows (at levels above the natural hydrological regime) in more than 90% of weeks for all three options. After providing non-consumptive generation and minimum instream flow benefits, water conveyed in natural stream channels can be taken downstream as far as the Tri-Cities to serve agricultural, municipal, commercial or industrial water supply requirements. The analysis of water demand provided in the U.S. Army Corps Report (Volume II) indicates that the primary future demand for water served by a large water storage project may be more likely downstream, out of basin.

These water, power and flood control benefits have the potential to provide very substantial benefits to Okanogan County and the State. For example, continuing with the High Dam option example, the water it makes available could irrigate about 487,000 acres of alfalfa or supply domestic water to 3.3 M households. The energy it could generate would be able to serve 15,000 households (at average District consumption rates). Water revenues could be as much as $65 M and power revenues could approach $13.9 M assuming a rather modest price of $0.06 kWh. Construction of the project would create 300 temporary jobs. It should be noted that the figures presented in Table ES-2 are based on gross water volumes and do not take into consideration operational plans with respect to water storage, hydropower and flood control. More thorough analyses of dam operations are needed to substantiate these figures.

The environmental benefits of the project include the ability to provide minimum instream flows of cool, clear water with higher concentrations of dissolved oxygen at appropriate times which could improve survival of all salmonid life stages, and increase the carrying capacity of other resident species such as freshwater mussels and mountain whitefish; the creation of a deep stratified layer which would provide fish with refugia from warm surface waters and large predators; and the ability to trap sediment and reduce downstream turbidity. As an example of habitat benefits provided, it would increase kokanee spawning habitat by 63% and would offset wetland and wildlife habitat losses by the creation of new open water and shoreline habitat partially offsetting habitat losses due to inundation. The project could provide instream flows benefiting as much as 618 miles of river (Similkameen, Okanogan and mainstem Columbia). It could provide minimum instream flow requirements through the summer and cool existing water temperatures in the Similkameen and upper Okanogan by as much as 2^{o} C.

The Medium and Low Dam options would have comparable benefits commensurate to their scale, as shown in Table ES-2.

Report Outline:

Chapter 1 provides an introduction, purpose, needs and objectives of the Project including Project history and background.

Chapter 2 gives descriptions of the options including those which were considered but not carried forward in this report. Project location and potential sitings and concept facility designs are provided. Spillways, outlets, penstocks and powerhouses are described in detail, with accompanying figures. Relocations and access considerations are given, as well as construction considerations, schedules and probable costs for all options.

Chapter 3 presents the engineering and environmental appraisals for each option, addressing engineering, water quality, aquatic resources, terrestrial resources: wetlands and wildlife, land use, recreation, cultural resources, and flooding effects on infrastructure and private property. A summary appraisal matrix is provided to highlight key information. Regulatory requirements are presented for the U.S. and Canada at the local, state/province and federal/national levels.

Chapter 4 presents conclusions and recommendations drawn from the appraisal evaluation presented in this report.

Table ES-1 Appraisal Evaluation Matrix.

ENGINEERING APPRAISAL		
High Dam Option	**Medium Dam Option**	**Low Dam Option**
Design: Earth fill dam with side slopes of 3H:1V on the upstream face and 2.5H:1V on the downstream face. Crest length approximately 1500 feet. Impervious core with pervious fill on either side and a rock-fill surface on both faces. Spillway set on the right bank with four radial gates, each 40 feet high x 50 feet wide. Low-level outlet is a 25-ft diameter steel pipe bored through rock beneath the right abutment of the dam. Low-level outlet would have a multi-port intake tower that allows water to be drawn from different levels in the reservoir for temperature and dissolved oxygen control. Combined flows through the spillway and low-level outlet would be able pass the PMF at full reservoir level.	**Design:** The dam would be a concrete gravity structure with a top elevation of 1190 feet and a crest length of about 550 feet. It would have a vertical upstream face and a slope of 1 vertical to 0.75 horizontal on the downstream side. Spillway located directly above the existing river channel and would be an integral part of the dam structure. Crest would be an ogee shape and have four radial gates, each 40 feet wide and 51 feet high. Spillway would discharge into a stilling basin that contains two rows of baffle blocks to dissipate energy. A 10-foot diameter low-level outlet pipe would be constructed through the dam between the spillway and the powerhouse. Intake gates positioned at varying depths would pass flow through to the powerhouse and allow discharge to be drawn from different elevations in the reservoir for possible control temperature and dissolved oxygen.	**Design:** The dam would be a concrete gravity structure with a crest length of about 500 feet. It would have a vertical upstream face and a slope of 1 vertical to 0.75 horizontal on the downstream side. Spillway located directly above the existing river channel and would be an integral part of the dam structure. Crest would be an ogee shape, a length of 500 feet and have four radial gates, each 40 feet wide and 51 feet high. Spillway would discharge into a stilling basin that contains two rows of baffle blocks to dissipate energy. A 10-foot diameter low-level outlet pipe would be constructed through the dam between the spillway and the powerhouse. Intake gates positioned at varying depths would pass flow through to the powerhouse and allow discharge to be drawn from different elevations in the reservoir for possible control temperature and dissolved oxygen.

High Dam Option	Medium Dam Option	Low Dam Option
Geotechnical: The dam site likely consists of argillite overlain with till and alluvium. The dam would be constructed on an argillite foundation, which is sufficiently strong to support the weight of the earth fill dam.	**Geotechnical:** The dam site likely consists of argillite overlain with till and alluvium. The dam would be constructed on an argillite foundation, which is sufficiently strong to support the weight of the medium height concrete gravity dam.	**Geotechnical:** The dam site likely consists of argillite overlain with till and alluvium. The dam would be constructed on an argillite foundation, which is sufficiently strong to support the weight of a concrete gravity dam.
Integration: Storage at the site of the hydropower dam in the upper Similkameen Basin is less than 10% of the total annual runoff at Shanker's Bend. Outflow would reduce flows in May and June and increase them in August through March.	**Integration:** Storage at the site of the proposed hydropower dam in the upper Similkameen Basin is less than 10% of the total annual runoff at Shanker's Bend. Outflow would reduce flows in May and June and increase them in August through March.	**Integration:** Storage at the site of the proposed hydropower dam in the upper Similkameen Basin is less than 10% of the total annual runoff at Shanker's Bend. Outflow would reduce flows in the May and June and increase them in August through March.
Key Sources: USACE previously studied similar dams at this location in 1948 and 1972. IJC evaluated this site in 1955.	**Key Sources:** USACE previously studied similar dams at this location in 1972. IJC evaluated this site in 1955.	**Key Sources:** USACE previously studied similar dams at this location in 1972. IJC evaluated this site in 1955.
Gaps: Source and availability of rock for the dam construction has yet to be identified. Additional geotechnical information would be required. To ascertain the back water raise to the reservoir elevations at high floods a hydraulic analysis is required.	**Gaps:** Source and availability of aggregate and sand for the concrete and location of a nearby batch plant have yet to be finalized. Additional geotechnical information would be required. To ascertain the back water raise to the reservoir elevations at high floods a hydraulic analysis is required.	**Gaps:** Source and availability of aggregate for the concrete and location of a nearby batch plant has yet to be finalized. Additional geotechnical information would be required. To ascertain the back water raise to the reservoir elevations at high floods a hydraulic analysis is required.

WATER YIELD AND GENERATION		
High Dam Option	**Medium Dam Option**	**Low Dam Option**
Water Volume: 1.3 million acre-feet of active storage. Maximum water surface elevation 1289 feet and minimum operating water elevation 1203 feet.	**Water Volume:** 138,000 acre-feet of active storage. Maximum water surface elevation 1175 feet and minimum operating water elevation 1134 feet.	**Water Volume:** 20,000 acre-feet of active storage. Maximum water surface elevation 1155 feet and minimum operating water surface 1134 feet.
Hydropower: A penstock would be built through the existing, abandoned railroad tunnel leading to a powerhouse at the southeast end of the tunnel. The tunnel would be expanded to accommodate a 20-foot diameter penstock. The powerhouse would have an installed capacity of about 74 MW, with a maximum flow of 5,000 cfs. Two Francis-type turbines would be used for power generation. Estimated annual energy output is about 232,000 MW-hrs.	**Hydropower:** Two penstocks would be constructed through the dam to the powerhouse located next to the left abutment at the dam's downstream base. The powerhouse would have an installed capacity of about 23 MW, with a maximum flow of 3,000 cfs. Two Kaplan-type turbines would be used for power generation. Estimated annual energy output is 84,000 MW-hrs.	**Hydropower:** Two penstocks would be constructed through the dam to the powerhouse located next to the left abutment at the dam's downstream base. The powerhouse would have an installed capacity of about 19.6 MW, with a maximum flow of 3,000 cfs. Two Kaplan-type turbines would be used for power generation. Estimated annual energy output is 70,000 MW-hrs.
Timing: The reservoir would be filled during spring months when high snowmelt flows are present in the river. Water would be drawn from the reservoir for irrigation and other uses during July, August, and into September.	**Timing:** The reservoir would be filled during spring months when high snowmelt flows are present in the river. Water would be drawn from the reservoir for irrigation and other uses during July and August.	**Timing:** The reservoir would be filled during spring months when high snowmelt flows are present in the river. Water would be drawn from the reservoir for irrigation and other uses during July and August.
Flood Control: Large storage capacity in the reservoir is sufficient to allow capture and attenuation of peak flood flows in all years modeled that would provide significant flood control benefits for downstream reaches.	**Flood Control:** Available storage in the reservoir would provide some ability to capture and attenuate peak flood flows in 91% of years modeled. Benefits would be significantly less than that which would be provided by the High Dam option.	**Flood Control:** Available storage in the reservoir would provide minimal ability to capture and attenuate peak flood flows in 76% of years modeled.

<table>
<tr><td>Key Sources:
Flow data for the Similkameen River was obtained from the USGS Gage near Nighthawk (Station #12442500). Estimates of hydropower from standard USBR turbine design guidelines.</td><td>Key Sources:
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<tr><th colspan="3">ENVIRONMENTAL EVALUATION</th></tr>
<tr><th>High Dam Option</th><th>Medium Dam Option</th><th>Low Dam Option</th></tr>
<tr><td>Land Use:
<u>Access</u>
Access would be reduced to the west of the reservoir. New roads would be built to maintain critical access in both the U.S. and Canada.

<u>Acres Inundated</u>
UNITED STATES:
▪ Agriculture: 272 acres
▪ Open Space: 3134 acres
▪ Resource Production & Extraction: 3504 acres
▪ Residential: 161 acres
▪ Cultural, Entertainment & Recreational: 42 acres
▪ Native American Trust lands: 1036 acres
▪ Transportation, Communication & Utilities: 150 acres
▪ Undeveloped Land: 617 acres
▪ Unclassified: 3523 acres
CANADA:
▪ First Nations Reservation: 6,000 acres
▪ Private Land: 2100 acres
▪ Crown Land: 800 acres
▪ Protected areas: 89 acres</td><td>Land Use:
<u>Access</u>
Access would be reduced to the west of the reservoir. New roads would be built to maintain critical access.

<u>Acres Inundated</u>
UNITED STATES:
▪ Agriculture: 109 acres
▪ Open Space: 1483 acres
▪ Resource Production & Extraction: 2009 acres
▪ Residential: 70 acres
▪ Cultural, Entertainment & Recreational: 22 acres
▪ Transportation, Communication & Utilities: 91 acres
▪ Undeveloped Land: 247 acres
▪ Unclassified: 2985 acres</td><td>Land Use:
<u>Access</u>
Effects on access would be minimal. New roads would be built to maintain critical access.

<u>Acres Inundated</u>
UNITED STATES:
▪ Agriculture: 39 acres
▪ Open Space: 275 acres
▪ Resource Production & Extraction: 392 acres
▪ Residential: 26 acres
▪ Cultural, Entertainment & Recreational: 7 acres
▪ Transportation, Communication & Utilities: 35 acres
▪ Undeveloped Land: 97 acres
▪ Unclassified: 2483 acres</td></tr>
</table>

High Dam Option	Medium Dam Option	Low Dam Option
Water Quality: ▪ Green benefits arise from providing a mix of cool, oxygenated water from multilevel intake tower, benefiting downstream anadromous fish and ameliorating existing problems ▪ Inundation of 7 mines would not be expected to cause important effects to water quality ▪ Ability to provide 100% of minimum instream flow requirements throughout the year ▪ Provide about 2°C cooler water to instream use during summer months ▪ Reduced turbidity downstream, benefiting salmonid spawning habitat. ▪ Reduced spring and increased summer discharge, potentially benefiting fish ▪ Ability to increase DO downstream through managed flow releases, benefiting aquatic resources.	**Water Quality:** ▪ Modeling would be required to establish the extent of potential green benefits from cool, oxygenated flow releases to benefit downstream anadromous fish and ameliorate existing problems. ▪ Inundation of one mine has no expected effects on water quality. ▪ Ability to provide 96% of minimum instream flow requirements throughout the year ▪ Potential to provide cold water releases downstream during summer. ▪ Reduced turbidity downstream, benefiting salmonid spawning habitat. ▪ Reduced spring and increased summer discharge. ▪ Increased DO downstream.	**Water Quality:** ▪ Modeling would be required to establish the extent of potential green benefits from cool, oxygenated flow releases to benefit downstream anadromous fish and ameliorate existing problems. ▪ No mines would be inundated. ▪ Ability to provide 92% of minimum instream flow requirements throughout the year ▪ Potential to provide cold water releases downstream during most of summer. ▪ Reduced turbidity downstream, benefiting salmonid spawning habitat. ▪ Reduced spring and increased summer discharge. ▪ Increased DO downstream

High Dam Option	Medium Dam Option	Low Dam Option
Aquatic Resources: ▪ The High Dam offers notable potential for green benefits, as cool, oxygenated flow releases may be timed and shaped to deliver water to benefit downstream anadromous fish and other instream environmental values. ▪ Minor negative impacts are largely limited to the inundation zone. Increased net productivity of aquatic life associated with an increase in available nutrients. ▪ Provide 100% of target instream flows during summer months ▪ Loss of 85,937 meters of mainstem fluvial habitat ▪ Increase in warm water recreational fishery ▪ 63% increase in potential kokanee spawning habitat with access to small tributaries ▪ 41% loss of spawning/rearing habitat in Canada ▪ Increase in carrying capacity of anadromous salmonids and other resident species ▪ Potential to increase recreational fishing opportunities	**Aquatic Resources:** ▪ Modeling would be required to establish the extent of potential green benefits from the release of cool, oxygenated flow releases to benefit downstream anadromous fish and other instream environmental values. ▪ Minor negative impacts are largely limited to the inundation zone. Increased net productivity of aquatic life associated with an increase in available nutrients ▪ Potential to support downstream fisheries during the summer ▪ Potential to provide consistent instream flow during summer months ▪ Loss of 27,809 meters of mainstem fluvial habitat ▪ 24% increase in potential kokanee spawning habitat ▪ Potential increase in recreational fishing opportunities	**Aquatic Resources:** ▪ Modeling would be required to establish the extent of potential green benefits from the release of cool, oxygenated flow releases to benefit downstream anadromous fish and other instream environmental values. ▪ Minor negative impacts are largely limited to the inundation zone. Increased net productivity of aquatic life associated with an increase in available nutrients ▪ Loss of 17,567 meters of mainstem fluvial habitat ▪ 13% increase in potential kokanee spawning habitat ▪ Potential increase in recreational fishing opportunities

High Dam Option	Medium Dam Option	Low Dam Option
Terrestrial Resources: <u>Wetlands:</u> ▪ 3,680 acres Eastside (Interior) Riparian-Wetlands inundated ▪ 3,654 acres Herbaceous Wetlands inundated ▪ 259 acres Montane Coniferous Wetlands inundated ▪ Possible wetland development on new shoreline areas <u>Wildlife:</u> ▪ Inundation of 6,717 acres priority riparian habitat in U.S. ▪ Inundation of 3,240 acres shrub-steppe/woodland habitat in U.S. ▪ Reduced habitat connectivity, both east-west and north-south ▪ Impacts to two provincial protected areas and a potential national grasslands park in Canada ▪ Major gain in open water habitat ▪ Loss of key white-tail and mule deer habitat ▪ Loss of 5 bald eagle nests ▪ Loss of 8,797 acres of cavity nesting duck habitat in US ▪ Loss of 1,844 acres of chukar habitat in US ▪ Impacts to ESA listed species: grizzly bear, gray wolf, lynx are improbable ▪ Possible impacts to 20 Canadian blue- and red-listed species ▪ Loss of big game and bird hunting, and wildlife watching opportunities ▪ Major gain in wildlife recreational opportunities if public access increases	**Terrestrial Resources:** <u>Wetlands:</u> ▪ 939 acres Eastside (Interior) Riparian-Wetlands inundated ▪ 2,615 acres Herbaceous Wetlands inundated ▪ 228 acres Montane Coniferous Wetlands inundated ▪ Possible wetland development on new shoreline areas <u>Wildlife:</u> ▪ Inundation of 4,850 acres of priority riparian habitat ▪ Inundation of 449 acres of shrub-steppe/woodland habitat ▪ Reduction in habitat connectivity, both east-west and north-south ▪ Gain in open water habitat ▪ Loss of key white-tail and mule deer habitat ▪ Loss of 3 bald eagle nests ▪ Loss of 6,933 acres of cavity nesting duck habitat ▪ Loss of 486 acres of chukar habitat ▪ Impacts to ESA listed species: grizzly bear, gray wolf, lynx are improbable ▪ Minor loss of big game and bird hunting, and wildlife watching opportunities ▪ Gain in wildlife recreational opportunities if public access increases	**Terrestrial Resources:** <u>Wetlands:</u> ▪ 221 acres Eastside (Interior) Riparian-Wetlands inundated ▪ 497 acres Herbaceous Wetlands inundated ▪ 140 acres Montane Coniferous Wetlands inundated ▪ Possible wetland development on new shoreline areas <u>Wildlife:</u> ▪ Inundation of 1,229 acres of priority riparian habitat ▪ Inundation of 210 acres of shrub-steppe/woodland habitat ▪ Gain in open water habitat ▪ Loss of key white-tail and mule deer habitat ▪ Loss of 1 bald eagle nest. ▪ Loss of 3,291 acres of cavity nesting duck habitat ▪ Loss of 229 acres of chukar habitat ▪ Impacts to ESA listed species: grizzly bear, gray wolf, lynx are improbable ▪ Minor loss of big game and bird hunting, and wildlife watching opportunities ▪ Minor gain to wildlife recreational opportunities if public access increases

High Dam Option	Medium Dam Option	Low Dam Option
Recreation: ▪ Palmer Lake cabins and campsites inundated ▪ Some access routes to recreational uses inundated; others would be rebuilt ▪ Gold prospecting sites inundated ▪ Portions of the proposed Oroville-Nighthawk Trail inundated ▪ Inundation affects access to one winery in the Canadian Similkameen Valley, and might affect orchards and vineyards ▪ Increased opportunities for flat water recreation, including boat fishing, jet skiing and sailing offsets impacts to current largely dispersed, informal recreational use ▪ Substantial new shoreline creates new opportunities for shore fishing, sightseeing, camping and hunting, and new recreation related waterfront development ▪ The presence of a large body of water in an arid environment may enhance aesthetics for some observers, offsetting any loss of visual quality associated with the loss of riparian vegetation and areas exposed during draw-down periods	**Recreation:** ▪ Some existing recreational facilities and sites would be inundated - primitive camp sites, cabins and recreational vehicle (RV) camping lots shore fishing areas ▪ Access routes to high elevation areas would be inundated - Iron Gate trailhead and for the Chopaka Mountain Wilderness Study Area (WSA) ▪ Gold prospecting sites would be inundated ▪ Increased opportunities for flat water recreation, including boat fishing, jet skiing and sailing offsets impacts to current largely dispersed, informal recreational use ▪ The new shoreline area would provide an opportunity for new recreation related waterfront development ▪ The expanded shoreline area would create new opportunities for shore fishing, sightseeing, camping and hunting ▪ The presence of an expanded body of water in an arid environment may enhance aesthetics for some observers, offsetting any loss of visual quality associated with the loss of riparian vegetation, impacts to habitat, and areas exposed during draw-down periods	**Recreation:** ▪ Some existing recreational facilities and sites would be partially inundated -primitive camp sites, cabins and recreational vehicle (RV) camping lots shore fishing areas - but access would be unaffected ▪ Gold prospecting sites would be inundated ▪ Inundation would enhance canoe and kayak access to some waterways and would create small amounts of new flat water for boat fishing, power boating, jet skiing, offsets impacts to current largely dispersed, informal recreational use ▪ The creation of some new shoreline areas would provide a small enhancement for shore fishing, sightseeing, camping and hunting ▪ The slightly expanded body of water in the area around Palmer Lake may enhance aesthetics for some viewers, offsetting any loss of visual quality associated with loss of riparian vegetation, impacts to habitat, and areas exposed during draw-down periods

High Dam Option	Medium Dam Option	Low Dam Option
Flooding: ▪ More than 12,000 acres of U.S. lands and structures inundated, valued at $25.5M ▪ Stranded land parcels valued at: $3.3M ▪ 8,995 acres of Canadian lands and structures inundated, valued at $7.3M – $16.7M (US$) ▪ 46.6 miles of U.S. roads and 13.8 miles of Canadian roads inundated (primarily Hwy 3 in Canada and County Road 9425 (Loomis Orville Highway) in the U.S., partially replaced by 21.2 miles of new roads ▪ Inundated US infrastructure: $61.1 million ▪ Total value of inundated lands and infrastructure $108M - $117M	**Flooding:** ▪ No Canadian lands inundated ▪ 7,605 acres of U.S. lands and structures inundated, valued at $13M ▪ Stranded land parcels valued at $1.93M ▪ 13.5 miles of US roads inundated (County Road 9425 [Loomis Orville Highway]), partially replaced by 12.4 miles of new roads ▪ Inundated US infrastructure: $24.2M ▪ Total value of lands and infrastructure: $37.2M	**Flooding:** ▪ More than 3,500 acres of U.S. lands and structures inundated, valued at $5M ▪ 2.9 miles of US roads inundated (primarily County Road 9425 [Loomis Orville Highway]), partially replaced by 3.2 miles of new roads ▪ Inundated US infrastructure: $5.7M ▪ Total value of inundated lands and infrastructure: $10.7M
Cultural Resources: ▪ 46 cultural and heritage resources would be affected ▪ High cultural importance sites that would be inundated include: ▪ Traditional cultural properties ▪ A burial site ▪ 4 pictograph sites ▪ 4 prehistoric housepits ▪ Multiple historic structures ▪ In Canada, 2 Indian Lands Southeast of Keremeos would be impacted	**Cultural:** ▪ 24 historic resources would be affected ▪ Several known resources considered to be of medium to high cultural importance would be inundated, including: ▪ Traditional Cultural Properties ▪ 1 pictograph site ▪ Multiple historic structures	**Cultural:** ▪ 16 historic resources would be affected ▪ Other than Traditional Cultural Properties in the area, the resources affected by this option are considered primarily of low to medium significance

Table ES-2 Benefits of the Similkameen Water Storage and Power Generation Project

Potential Project Benefit	Option 1: High Dam	Option 2: Medium Dam	Option 3: Low Dam
Water Storage Benefits			
Total water storage volume (acre-feet)[1]	1,700,000	168,000	50,000
Annual usable water (ac-ft/yr)	1,300,000	138,000	20,000
Equivalent irrigation potential (acres of alfalfa) [2]	487,000	51,700	7,500
Equivalent domestic water service (number of residences)[3]	3,100,000	329,000	48,000
Power Generation Benefits			
Capacity (MW)	74	23	19.6
Annual Average Generation (MWh)	232,000	84,000	70,000
Equivalent domestic energy service (number residences)[4]	15,200	5,500	4,600
Flood Control Benefits			
Potential flood storage[1]	1,300,000	138,000	20,000
Inability to attenuate flood (% weeks failed between 1931-2007)[5]	0%	0.05%	0.08%
Economic Benefits			
Water revenue[6]	$65,000,000	$6,900,000	$1,000,000
Power revenue[7]	$13,900,000	$5,000,000	$4,200,000
Cost Ratio ($/ac-ft)	$855	$2,820	$16,200
Job creation	300 for 48 months	170 for 36 months	150 for 36 months
Environmental Benefits			
Downstream river habitat improved (River)	Similkameen and Okanogan	Similkameen	Similkameen
Ability to meet minimum instream flow (MIF) requirements (% weeks met MIF between 1931-2007)	100%	96%	92%
Provision of cool water, with higher DO concentrations	2ºC would meet 18 ºC target	Possible 2ºC probably meet 18 ºC target	1-2ºC may meet 18 ºC target
Improve survival of salmonids	Probable	Probable	Possible
Increase amount of Kokanee spawning habitat	63%	24%	13%

[1] Water and flood storage potential depends upon operations, which have not yet been defined in detail.
[2] Based on a water duty of 2.67 ac-ft of water per acre for alfalfa (derived from crop use by Okanogan Irrigation District)
[3] Based on an average water use rate of 150 gpd/person (Washington Department of Health) and an average household size of 2.5 persons/residence (State of Washington Department of Community, Trade & Economic Development, Washington Prospector: Buildings, Land & Site Selection Analysis, Demographic Report, Okanogan County, 2008).
[4] Based on an average power consumption of 15,300 kWh per household per year.
[5] Refer to Volume II of this report.
[6] Based on an assumed annualized saled price of $50 per acre-foot.
[7] Based on an assumed price of $0.06 per kWh.

Conceptual level cost estimates for each dam option were made based on the drawings and descriptions contained in this document and are shown below in Table ES-3.

Table ES-3 Probable Construction Costs

Probable Construction Costs		
Option 1: High Dam	**Option 2: Medium Dam**	**Option 3: Low Dam**
$1,020,160,000	$329,000,000	$289,000,000

These cost estimates should be considered Class 5, as designated by the Association of American Cost Engineers (AACE), for which engineering is typically 0% to 10% complete. Expected accuracy ranges are from -20% to 100%. These estimates are primarily for comparative purposes and not intended to be used for economic analyses and financial planning. All costs are given in 2008 dollars. No mitigation costs were included in the estimate. Owners' soft costs or program expenses have also been excluded. See Appendix B for a line-item breakdown of material costs.